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TRANSLATION

DEVICE FOR MEASURING TEMPERATURE COEFFICIENTS
OF SMALL MAGNETS

By

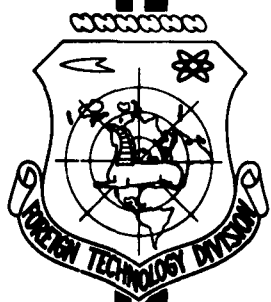
V. N. Bobrov

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CIENTS OF SMALL MAGNETS

BY: V. N. Bobrov

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DEVICE FOR MEASURING TEMPERATURE COEFFICIENTS OF SMALL MAGNETS

V. N. Bobrov

Described here is a device intended for rapid measurement of temperature coefficients of small magnets with temperature coefficients $\mu \geq 10^{-6}$.

Owing to the organization at The Institute of Terrestrial Magnetism, Ionosphere, and Propagation of Radio Waves of the Academy of Sciences USSR (IZMIRAN) of the serial production of quartz geomagnetic devices [1], [2] which use small magnets having small temperature coefficients, it has become necessary to develop a device for measuring temperature coefficients μ which provide: 1) the possibility of measuring μ for magnets with moments $M < 1$ CGS, 2) the possibility of measuring values of $\mu \approx 10^{-6}$, 3) high accuracy and rapid measurements.

The device developed earlier by the author [3] does not satisfy the first two requirements.

A short report is presented below of a new device produced in 1960. Two years of use have shown that the device has high qualities.

The base of the device (Fig. 1) is quartz sensing element 1

enclosed in an air-tight housing 2. A magnet with magnetic moment less than 0.5 CGS is used as the suspension system of the sensing element. The suspension system is adjusted by delicate untwisted threads in a zero magnetic field. The housing with the sensing element is fastened to clamp 3 rigidly secured to base 4 which is made in the form of a flat disk with three adjustment screws. On the clamp below the housing is fastened a rotating rod 5 with magnet 6 which serves to change the scale division of the sensing element. Above the housing is rigidly fastened rod 7 with comagnet 8 which is used if necessary to change the field at the center of the sensing element. Above the clamp is fastened busbar 9. Along it runs carriage 10 with rod 11 at the end of which is the investigated magnet 12.

The scale division of the sensing element is determined by means of rotatable magnet 13 with a known magnetic moment. The deflection angle of the magnet is reckoned by the degree divisions plotted on head 14. If the examined magnet has a larger temperature coefficient, then rotatable magnet 13 is used directly to measure the field produced by the change of temperature of the examined magnet (null method). The readings on the device are taken by an ordinary telescope 15. In a number of cases it is more expedient to remove the telescope and to take the readings by means of an additional scale and illuminator placed at a certain distance from the device. In this case the scale division and the field caused by the temperature change of the examined magnet are determined electrically. For this purpose, on the lateral surface of the housing of the sensing element is one loop of wire 16 with a known constant.

The sensing element is adjusted to a scale division of the order of 1 γ per division. With the aid of comagnet 6 the scale division,

when needed, can be reduced to 0.05 γ and less.

The temperature coefficient on the described device is measured in the following way. The device stands so that a line, crossing through the center of the suspended magnet and the examined magnet, is situated perpendicular to the magnetic meridian. Then, moving the carriage with the examined magnet, such a position is obtained that the horizontal component H will be compensated at the center of sensing element. After that, the magnet is dipped successively in vessel 17 with cold and hot water and the change in the readings of the device ΔH are recorded. The changes ΔH are recorded either directly by the telescope scale or by the complementary scale or by the deflection angle of magnet 14 with a null method of reading.

The temperature coefficient μ is calculated by the formula:

$$\mu = \frac{\Delta H}{H \Delta t}.$$

where Δt is the temperature difference of the cold and hot water. If the examined magnet has a very small magnetic moment and it is practically impossible for it to compensate the horizontal component H, then in this case comagnet 8 is used which creates at the center of the sensing element the known field H_1 . Then μ is calculated by the formula:

$$\mu = \frac{\Delta H}{(H - H_1) \Delta t}.$$

A model of the device produced in IZMIRAN allows adjustment to a scale division up to 0.05 γ and permits determination of temperature coefficients up to 10^{-6} . Actually if $H = 20000\gamma$, $\Delta t = 80^\circ$, $\Delta H = 1.6\gamma$, then $\mu = 10^{-6}$.

The error of determining μ will depend on disregarding variations of the horizontal components when reading the device. However, this

error is sufficiently small if we consider that the individual measurement of μ on the instrument takes no more than 10 seconds and the calculation of μ is the result of averaging certain successively performed determinations. The rate of determination of μ (10 sec) is determined by the time during which the small magnet assumes the temperature of the surrounding water.

We can disregard the error of determination of μ caused by the linear expansion of busbar 9 since the solid busbar in such a short interval of time does not change its temperature. To ensure this, a heat insulating plate protecting the busbar from heat is attached to carriage 10 below the busbar.

The error of determination of μ caused by linear expansion of rod 11 can be estimated in the following way. Let the rod length be 100 mm, and the coefficient of linear expansion of brass be $2 \cdot 10^{-5}$. Then upon heating of the rod, the displacement of the magnet will equal 0.1 mm per 50° on the average. If the distance between the examined magnet and the suspended magnet is 50 mm, then the error of determination of μ will equal 0.03 γ .

The error is calculated by the formula

$$d\Delta H = H \left[1 - \frac{R^2}{2R_1^2} (2\cos^2\alpha - \sin^2\alpha) \right],$$

where $H = 20000 \gamma$, $R = 50 \text{ mm}$,

$$R_1 = \sqrt{50^2 + (0.1)^2}, \quad \sin\alpha = 0.002.$$

To increase the accuracy of measuring the temperature coefficients of magnets with $\mu \approx 10^{-6}$, it is desirable to make the busbar and rod from quartz, whose coefficient of linear expansion is two orders less than that of brass.

In conclusion the author expresses gratitude to glassblowers

N. D. Kulikov and A. I. Bushuyev for preparing the device.

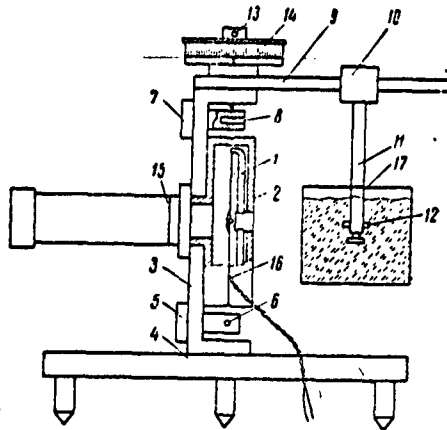


Fig. 1.

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